Global Advanced Research Journal of Biochemistry and Bioinformatics Vol. 1(2) pp. 026-030, August, 2012
Available online http://garj.org/garjbb/index.htm

Full Length Research Paper

Effect of cooking on the nutritional and phytochemical components of trifoliate yam (*Dioscorea dumetorum*)

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Accepted 21 August, 2012

Trifoliate yam (*Dioscorea dumetorum* pax) obtained from the yam programme of National Root Crops Research Institute; Umudike was assessed to determine if cooking duration had any effect on their nutritional and phytochemical components. The tubers were cooked for 30mins, 60mins and 90mins, the nutritional and anti-nutritional compositions were evaluated while the Gas chromatography/ mass spectrophotometer (GC/MS) was used to identify the phytochemical components. Significant differences were observed in the proximate composition of the raw and the cooked tubers. Cooking for 90 minutes caused 29.81% loss in the crude protein of *D. dumetorum*. Cooking also affected the ash and fibre contents but the lipid content was not significantly affected. Cooking significantly reduced the alkaloid, saponin and flavonoid composition in *Dioscorea dumetorum*. The number of phytochemical compounds identified in the tubers cooked for 90 minutes were higher than those identified in the raw tubers. The Compounds identified in the tubers include fatty acids, phenols, hydrocarbons, esters, alcohols, aldehydes and ketones. The results obtained from the study showed that there were obvious quantitative and qualitative differences in the nutritional composition and phytochemical profile of raw and cooked tubers.

Keywords: *Dioscorea dumetorum*, Cooking, Fatty acids, anti-nutritional composition, Proximate composition

INTRODUCTION

Yam (Dioscorea spp) is an economically important food in many tropical countries particularly in West Africa and Caribbean, where it also has a social and cultural importance (Manuel *et al*., 2005). By virtue of its excellent palatability, yam is a high value crop widespread throughout the world and forms about 10 % of the total roots and tubers produced in the world (FAO, 2004). The trifoliate yam, (*Dioscorea dumetorum* Pax), belongs to the family Dioscoreaceae and genus Dioscorea (Bai and Ekanayake, 1998). *Dioscorea dumetorum* originated in tropical Africa and occurs in both wild and cultivated forms but its cultivation is still restricted in West and Central Africa (Alozie *et al*, 2009). Root crops are not easily digested in their natural state and should be cooked before they are eaten. Cooking improves their digestibility, promotes palatability and improves their keeping quality as well as making the roots safer to eat. *Dioscorea dumetorum* has not been as widely studied as other species. There is need however to investigate on the components of this under-utilized specie of yam. This will

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be useful for potential uses of the tuber in the food industry, animal feed industry and cosmetic or pharmaceutical industry. Additionally, increased study on *Dioscorea dumetorum* could add to the likelihood of exploitation of the species as an economic plant and bring about further work on its cultivation. It is also important to verify if the phytochemical profile is affected during cooking, if so, to what extent. The objective of this work therefore is to identify, quantify and compare the nutritional and phytochemical composition of the raw and boiled tubers of *D. dumetorum*

MATERIALS AND METHODS

Dioscorea dumetorum (the light yellow cultivars) was obtained from the yam programme of National Root Crops Research Institute, Umudike. The tubers were washed and divided into 2 portions of 1kg each. One portion was peeled, washed and chipped with a chipping machine. The chips were then air dried. The second portion was washed and cooked by boiling in distilled water at 100^{o}C for 30 minutes, 60 minutes and 90 minutes; peeled and chipped with the chipping machine. The chips were spread thinly on a dark nylon and air dried. The dried yam chips were then milled into powder using a Thomas Wiley mill model ED-5

and stored in air tight containers before analysis. The proximate analysis was carried out using the AOAC, (1990) method. The method of Obadoni and Ochuko (2001) was used to determine the alkaloid, saponin, phenol, flavonoid and tannin content of the raw and cooked yam. Compounds present in the soxhlet ethanol extract were identified by GC-MS analysis using a Perkin-Elmer GC-MS Clarus 500 linked to Elite 5 MS Column with a length of 20 m and internal diameter of 0.18µ. The temperature was programmed from 200^{o}C to 300^{o}C at a rate of 4oC min-1 with 10 minutes hold. Injector was at 200℃. The carrier gas was Helium with a constant flow at 1ml/min. Mass method used was Electron Ionization with ionization voltage of (EI+) 70 eV for m/z value 50 to 300 with a scan time of 0.3 sec and interscan delay of 0.1 sec. Interpretation on mass-spectrum GC-MS was conducted using the database of National Institute Standard and Technology (NIST). The spectrum of the unknown components was compared with the spectrum of known components stored in the NIST library.

The name, molecular weight and structure of the components of the test materials were ascertained while the quantities were represented as relative area % as derived from the intergrator.

RESULTS

The results of the proximate composition of the tubers are presented in Table 1. Table 2 shows the anti-nutritional composition of the tubers while Table 3 shows the phytochemical profile of the raw and boiled tubers. These results show that the proximate and anti-nutritional composition of trifoliate yam (*Dioscorea dumetorum*) vary greatly with cooking period. The crude protein (11.41%), Ash (2.23%), lipids(0.71%), crude fibre(2.03%) contents obtained for the raw tubers were significantly higher (P<0.05) compared to the crude protein (8.01%), Ash (1.51%), lipids(0.54%) and crude fibre(1.62%) contents obtained for the samples which were boiled for 90 minutes. However, the carbohydrate (77.55%) and energy (361.90kcal/100g) contents of the raw samples were significantly lower than the carbohydrate (84.16%) and energy (373.46 kcal/100g) contents of the samples which were boiled for 90 minutes.

The anti-nutritional compositions of *D. dumetorum*, are shown in Table 2. Similarly, the alkaloid (3.08%), saponin (3.36%), phenol (1.83%), flavonoid (0.66%) and tannin (0.32%) contents of the raw sample were higher than those of the samples which were boiled for 90minutes. The level of alkaloids in the trifoliate yam reduced to 0.210% when boiled for 90 minutes. The GC-MS data for the raw and boiled *Dioscorea dumetorum* are summarized in Table 3. The main fatty acids identified in the *D. dumetorum* were Oleic acid, linoleic acid and Palmitic acid. Others include lauric acid, n-Pentadecylic acid and 1-Tridecane carboxylic. The total concentration of fatty acids in the raw *D. dumetorum* was 39% while boiled *D. dumetorum* had a total fatty acid concentration of 103.9%. About 14.769% linoleic acid was identified in the boiled *D. dumetorum* while none was detected in the raw tuber. The most abundant saturated fatty acid was palmitic acid. The raw *D. dumetorum* contains 25.14% palmitic acid while the boiled sample contains 15.077%, showing that the concentration reduced with boiling. The esters identified in the tubers include: 9,12-octadecadienoic acid (Z,Z)-2-Hydroxy-1-(hydroxymethyl) ethyl ester, Glycerol-1- monolinolate, 2-Hexadecanoyl glyceride, Methyl (9E,12E)-9,12 octadecadienoate and 3-Hydroxycholestan-5-yl acetate. The main phenol identified in the trifoliate yam was 3, 5-Di-T-butyl phenol which was present in both the raw and boiled tubers. The raw *D. dumetorum* possessed 1.18% of 3, 5-Di-t-butyl phenol, when it was boiled for 90mins, the concentration increased to 1.42%. Cholest-5-en-3-ol was identified in both the raw and boiled tubers. The concentration of cholest-5-en-3-ol in the boiled sample (7.39%) was higher than in the raw sample (5.58%).

DISCUSSION

The proximate composition of trifoliate yam showed that all the analyzed components were significantly higher (p<0.05) in the raw tubers than in the boiled tubers except the carbohydrate which increased after boiling. Protein content of the raw tuber was 11.405%, which is similar to the result obtained by Alozie *et al*, (2009). The crude

Table 1. Effect of cooking on the proximate composition of cultivated *D. dumetorum.*

Samples	Ash(%)	Lipids(%)	Moisture(%)	Fibre(%)	Protein(%)	CHO(%)	Energy(kcal/100g)
ROO	2.23a	0.71a	6.10a	2.03a	11.41a	77.55d	361.90d
OB30	1.91b	0.65b	5.25b	1.86b	10.30b	80.09c	367.21c
OB60	1.74c	0.59c	4.91c	1.73c	9.41c	81.63b	369.45b
OB90	1.51d	0.54d	4.18d	1.62d	8.01b	84.16a	373.46a

Means with different letters on the same column are significantly different (P<0.05)
Where ROO = Raw D. dumetorum, OB30 = D. dumetorum boiled for 30mins, OB60 = D. dumetorum boiled for 60mins, OB90 = D. dumetorum boiled for 90mins

Table 2. Effect of cooking on the phytochemical composition of cultivated *D. dumetorum.*

Samples	Alkaloid(%)	Flavonoid(%)	Saponin(%)	Tannin(%)	Phenol(%)
ROO	3.08^{a}	0.66^{a}	3.36^{a}	0.32^{a}	1.83^{a}
OB30	2.33^{b}	0.51^{b}	2.92^{b}	0.28^{b}	1.16^{c}
OB60	0.67^{c}	0.16^{d}	1.52^{c}	0.24^{c}	1.15^{c}
OB90	0.21^{d}	0.32^{c}	1.51^{c}	0.15^{d}	1.54^{b}

Means with different superscript on the same column are significantly different (P<0.05)
Where ROO = Raw D. dumetorum, OB30 = D. dumetorum boiled for 30mins, OB60 = D. dumetorum boiled for 60mins, OB90 = D. dumetorum boiled for 90mins

protein contents reduced significantly (p<0.05) with increase in the boiling time. Boiling effected a 29.81% reduction in the crude protein of *D. dumetorum*. This reduction may be as a result of the loss of free amino acids which take place through leaching. Boiling *D. dumetorum* for 90 minutes resulted to 32.29% loss of its ash content; this could be as a result of leaching of the minerals into the boiling water. The observed decrease in ash content after cooking implies that the potential ability of the tuber to supply essential minerals has been reduced. The crude fibre content of *D. dumetorum* reduced significantly with boiling. The carbohydrate contents of trifoliate yam (77.545%) agrees with the work of Ogbuagu, (2008) which reported that the dry matter of most root and tuber crops is made up of about 60-90% carbohydrate. The carbohydrate values are comparable to that obtained by Longe (1986) for white yam (78%), water yam (75.65%) but lower than the carbohydrate value for sweetpotato (82.55%). The carbohydrate composition of trifoliate yam increased significantly (p<0.05) with boiling time.

Boiling resulted in reduction of all the anti-nutritional components analyzed in this study as shown in table 2. The reduction increased as boiling period increased. This trend may be due to higher ability of hydrolyzing the anti-nutrients as boiling period increased. The determination of the anti-nutritional composition was of interest because of the toxicity of some of them, negative effects on mineral bioavailability and their pharmacological effect. The raw *D. dumetorum* had 3.36% of saponin. The saponin and alkaloid levels in the boiled samples were reduced significantly when compared to the raw sample. Most alkaloids are known for their pharmacological effects rather than their toxicity. However when alkaloids occur in high levels in foods, they cause gastro-intestinal upset and neurological disorders (Okaka *et al*, 1992). Flavonoid concentrations were significantly affected by boiling (p<0.05), this confirms the work of Mcwilliams (1979) which reported that flavonoids are destroyed by heat processing methods like drying, roasting and boiling. The level of tannin which the plant probably uses for defense (Aletor, 1993) was found in smaller quantities than other phytonutrients determined in the trifoliate yam tubers. Tannin affects the nutritive value of food products by forming complex with protein (both substrate and enzyme) thereby inhibiting digestion and absorption (Osuntogun *et al*, 1987). They also bind iron making it unavailable (Aletor and Adeogun, 1995). The tannin content of the trifoliate yam reduced with boiling, 54% tannin destruction was observed. The decrease in the levels of tannin during cooking may be due to the thermal degradation and denaturation of the tannin as well as the formation of insoluble complexes (Kataria *et al*, 1989).

The number of compounds identified in the cooked tubers was higher than that identified in the raw tubers. This agrees with the work of Josephson, (1991) that heating process makes hidden components become visible and identifiable. This can be attributed to a complex series of thermally induced reactions which occur in the food

Table 3. Compounds identified in the raw and boiled *Dioscorea dumetorum*.

Compounds	RT	MOL.WT	% concentration	
			Raw	Boiled
Fatty acids				
Linoleic acid	34.34	280	ND	14.769
Trans-octadec-9-enoic acid	34.43	282	ND	17.538
Lauric acid	25.77	200	0.559	ND
n-Pentadecylic acid	31.35	242	5.587	ND
Palmitic acid	32.7	256	25.14	15.077
Cis-Oleic acid	34.75	282	11.173	ND
1-Tridecane carboxylic acid	29.91	228	2.235	1.231
PHENOLICS				
3,5-Di-t-butyl phenol	23.63	206	1.117	1.538
trans-3,4,4,5-tetramethoxychalcone	40.01	328	ND	0.923
STEROLS				
cholest-5-en-3-ol	44.53	386	5.587	7.385
Aldehydes and Ketones				
trans, trans-2,4-decadienal	17.28	152	ND	0.615
ALCOHOLS				
E,E,Z-1,3,12-Nonadecatriene-5,14-diol	38.9	354	ND	9.231
9,12-Octadecadien-1-ol	34.38	266	33.52	ND
HYDROCARBONS				
(3Z)-3-Hexadecene	19.98	224	ND	0.615
ESTERS				
9,12-octadecadienoic acid (Z,Z)-2-Hydroxy-1-(hydroxymethyl)ethyl ester	38.85	354	6.15	ND
Glycerol-1-monolinolate	38.85	354	ND	9.231
2-Hexadecanoyl glyceride	37.46	330	7.821	12.308
Methyl(9E,12E)-9,12-octadecadienoate	33.91	294	ND	5.538
3-Hydroxycholestan-5-yl acetate	44.55	446		7.39
AMINES				
Crodamide	36.22	281	1.117	ND
Bis{2-(Dimethylamino)ethyl}	35.72	160	ND	2.462
Furan				
5-Methyl-5-(4,8,12-trimethyltridecyl)dihydro-2(3H)-furanone	36.27	324	ND	1.538

Where RT= retention time ND = not detected

resulting in a number of reaction products (Mottram, 1998). Plant fatty acids serve as good and healthy fat to the consumers, linoleic acid, an essential fatty acid found in *Dioscorea dumetorum* varieties is an indicator, pointing to the need to exploit these yams for their nutritional values. 9, 12, Octadecadienoic acid (Linoleic acid) has antiinflammatory and antiarthritic properties (Baranwal *et al*, 2012). A lack of LA and other n-6 fatty acids in the diet causes dry hair, hair loss, (Cunnane and Anderson, 1997) and poor wound healing (Ruthig and Meckling-Gill, 1999). Cis-Oleic acid was identified in both the raw and boiled *D. dumetorum* while the isomer trans-octadec-9-enoic acid was identified in the tubers boiled for 60 and 90 minutes. The isomerization may have been as a result of heat application (Mateos *et al*, 2010). Oleic acid may help boost memory (Valeria *et al*, 2001). Oleic acid may be responsible for the hypotensive (blood pressure reducing) effects of olive oil (Teres *et al*, 2008). Lauric acid is a saturated fatty acid with a 12 carbon atom chain and has been proven to have antimicrobial properties (Hoffman *et al*, 2001) (Ouattar *et al*, 2000) (Dawson *et al*, 2002). It is present in the raw *D. dumetorum* (0.559%) but absent in the boiled tubers. The total fatty acid increased on boiling. Esters are generally the result of esterification of carboxylic acids and alcohols. They are important because they impact flavours on foods. The concentration of esters in the boiled tubers was higher than in the raw tubers.

Phenolics usually posses antimicrobial and antifungal activities; and consequently defensive functions (Mitova *et al*, 2003). 3, 5-Di-t-butyl phenol which was identified in the tubers, is a lipophylic (fat soluble) organic compound, chemically a derivative of phenol. It is important because of its antimicrobial, antioxidant, anti inflammatory and analgesic properties. Trans-3,4,4,5-tetramethoxy chalcone identified in the boiled *D. dumetorum*. Chalcones are known as the precursors of all flavonoid type natural products in biosynthesis (Jamal *et al*, 2009). Cholest-5-en-3-ol was identified in the raw tuber but not detected in the boiled tubers. Trans-Trans- 2, 4-decadienal was identified in the *D. dumetorum* tubers which were boiled for 30 and 60mins. It is a Dienaldehyde, Dienaldehydes are by-products of peroxidation of polyunsaturated lipids and commonly found in many foods or food-products (Petersen *et al*, 1998).

CONCLUSION

Results illustrated that there were obvious quantitative and qualitative differences in the nutritional composition and phytochemical profile of raw and cooked tubers. *D. dumetorum* is recommended in human and animal nutrition or in livestock industries. The findings of this study therefore opens up new areas of research in the utilization of *D. dumetorum* in functional food production.

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